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(54) POROUS POLYSULFONE FILM

(57)Abstract:

PROBLEM TO BE SOLVED: To prevent bacterial lump pieces contained in a dialysis liquid from penetrating into the inside of a hollow fiber film which consists of a polysulfone resin and a hydrophilic polymer and has a dense layer at the inner surface side and a porous part on the outer surface by setting the ratio of pores each having a specified pore area, the average pore area, and the ratio of opening, each in a specified ratio.

SOLUTION: In a hollow fiber film which is suitably used for blood dialysis, blood filtration, and blood dialysis filtration, consists of a polysulfone resin and a hydrophilic polymer, and has a dense layer at the inner surface side and a porous part on the outer surface, the ratio of opening of the porous part on the outer surface is set at 10-30%; the ratio of pores each having a pore area of $0.5 \mu\text{m}^2$ or higher, at 10% or lower; the ratio of pores each having a pore area of $0.1 \mu\text{m}^2$ or lower, at 75% or lower; and/or the average pore area on the outer surface, in a range of $0.05-0.35 \mu\text{m}^2$. Thus, hollow fibers are prevented from adhering to each other, and simultaneously the penetration of bacterial lump pieces from a contaminated dialysis liquid into the inside of the film can be inhibited.

Polyvinylpyrrolidone is preferable as the hydrophilic polymer.

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CLAIMS

[Claim(s)]

[Claim 1] It is the hollow fiber which consists of polysulfone system resin and a hydrophilic macromolecule, has a compact layer in an internal-surface side, and has an aperture in an outside surface. a hole [in / in the hole density of the aperture in an outside surface / 10 – 30%, and an outside surface] -- area -- 0.5micrometer² the abundance of the above hole -- 10% or less and a hole -- area -- 0.1micrometer² the abundance of the following holes is 75% or less -- and/or, the average hole area in an outside surface -- 0.05–0.35micrometer² it is -- polysulfone system porous membrane characterized by things.

[Claim 2] Polysulfone system porous membrane according to claim 1 characterized by a hydrophilic giant molecule being a polyvinyl pyrrolidone.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]**[0001]**

[Field of the Invention] This invention is used about the medical-application demarcation membrane aiming at removal of the wastes in blood by extracorporeal circulation in the hemodialysis for substituting for blood purification, especially a kidney function, hemofiltration, and the field of hemofiltration dialysis.

[0002]

[Description of the Prior Art] In recent years, dialysis using permeable membrane is performed by the fall of a kidney function to a patient with the low wastes removal capacity in blood, a patient's prolongation of life is made, and it is. On the other hand, the complication called dialysis amyloidosis has appeared with protraction of such dialysis. This is a disease which the fiber protein called amyloid carries out deposition to a ligament, a tendon, a joint, etc., and brings about various clinical manifestations. Since beta 2-microglobulin was identified as one of the proteins which constitute this amyloid, removal of these low-molecular protein is one of the therapy targets, and the commercial-scene demand of the high performance permeable membrane which makes it possible has increased. Although it is the high removal engine performance and the outstanding biocompatibility of the low-molecular protein represented by beta2-microglobulin as a property for which high performance permeable membrane is asked, the polysulfone system resin which is synthetic macromolecule as a film material with which are satisfied of these attracts attention, and development of the high performance permeable membrane which makes polysulfone system resin a subject is furthered positively.

[0003] However, if polysulfone system resin has high hydrophobicity and it remains as it is, since water wettability is bad, a filtration efficiency cannot fully demonstrate it. Furthermore, when used in the blood purification field like this invention, it is necessary to control activation of a blood coagulation system, and in order to carry out hydrophilization of the film front face, hydrophilization agents, such as a hydrophilic macromolecule and a glycerol, are added in many cases. Since these hydrophilization agents exist in a film front face, as a result of fixing arising by the film by which a hydrophilization agent achieves the duty of a paste and adjoins at the time of the desiccation in a manufacture process, poor molding by poor osmosis of a potting agent might occur.

[0004] The attempt which improves this fault is indicated by JP,7-289863,A as a technique which mitigates the touch area of the film which make a big aperture to the outside surface of a hollow fiber, and adjoin it. however -- while the water quality management situation of dialysing fluid improved by leaps and bounds by use of an endotoxin cut-off filter -- ****, such as a dialysing fluid supply coupler, -- the dialysing fluid contamination incidentally depended was still generated, and the piece of a sulfur granule which peeled and fell from the coupler at the time of use may have invaded into the porosity section inside the film from the aperture of a film outside surface. And in these high performance permeable membrane, there was a possibility of the endotoxin isolated from the piece of a sulfur granule with the physical shock at the time of invasion having penetrated a compact layer, having shifted to a blood side, and stimulating a living body.

[0005]

[Problem(s) to be Solved by the Invention] Moreover, this invention aims at offering the polysulfone

system porous membrane by which the piece of a sulfur granule contained in dialysing fluid does not trespass upon the interior of the film, without causing poor molding by film fixing at the time of manufacture.

[0006]

[Means for Solving the Problem] In the hollow fiber which consisted of polysulfone system resin and a hydrophilic macromolecule, had a compact layer in the internal-surface side, and had an aperture in the outside surface as a result of inquiring wholeheartedly, in order that this invention persons may solve the above-mentioned technical problem When abundance of a specific hole area, average hole area, and hole density were made into the specific range, it resulted it not only can prevent fixing of hollow filaments, but that it could prevent invasion to the interior of the film of the piece of a sulfur granule originating in contamination dialysing fluid to high rate in the header, and this invention was resulted in *****. Namely, this invention consists of polysulfone system resin and a hydrophilic macromolecule. a hole [in / in the hole density of the aperture / in / it is a hollow fiber and / an outside surface / which has a compact layer in an internal-surface side, and has an aperture in an outside surface / 10 – 30%, and an outside surface] -- area -- 0.5micrometer² The abundance of the above hole at 10% or less and a hole -- area -- 0.1micrometer² the average hole area in that the abundance of the following holes is 75% or less, and/or an outside surface -- 0.05–0.35micrometer² it is -- it is related with the polysulfone system porous membrane characterized by things.

[0007] Although the film of this invention consists of polysulfone system resin and a hydrophilic macromolecule, the main components which constitute the film are polysulfone system resin, and consist of a chemical structure type (1) shown below or repeat structure of the unit of (2). The so-called polysulfone derivative which the functional group and the alkyl group combined on the ring besides this is also contained under the category of this invention. In addition, Ar in a formula shows the bivalence phenyl group of the Para permutation.

-O-Ar-C(CH₃)₃-Ar-O-Ar-SO₃-Ar- (1)

-O-Ar-SO₃-Ar- (2)

[0008] The second component which constitutes the film is a hydrophilic macromolecule, and is mainly added for the purpose of membranous hydrophilization and hole formation. A hydrophilic giant molecule dissolves in polysulfone system resin and a common solvent, and the point of having compatibility to a vinyl system giant molecule is desirable, for example, can choose it from a polyvinyl pyrrolidone, a polyethylene glycol, a polyamide, polyvinyl alcohol, and an ethylene–vinylalcohol copolymer. Especially, since a polyvinyl pyrrolidone has polysulfone system resin and moderate compatibility, remains in a film front face and can be contributed to the formation of an anti-thrombus and filtration efficiency by hydrophilization, it is the most desirable. Since what is necessary is have just carried out the hydrophilization of the film front face finally about the content of these hydrophilic macromolecules, it is enough if it is 3 – 12 % of the weight. It is 5 – 9 % of the weight more preferably. Therefore, the membranous remaining part and 88 – 97 % of the weight are polysulfone system resin.

[0009] The structure of the porous membrane of this invention has the shape of a hollow filament with the centrum whose bore is 80–400 micrometers, and the thickness section whose thickness is 35–85 micrometers, and has pressure resistance and tensile strength sufficient as a blood purification application. If a bore is less than [this] small, vascular resistance increases and a flow velocity cannot be secured, but even if it becomes large beyond the need, the mass transfer effectiveness in blood falls and it leads to the fall of a curative effect. Moreover, if thickness is too thin, it will cause crushing and leak, without the ability maintaining reinforcement, if too thick, the mass transfer resistance in the film will become large, and penetrable ability will fall. the hole moreover controlled by nothing and the outside surface which touches dialysing fluid in the unsymmetrical structure where this hollow fiber is from the layer of condensation and rarefaction as a base material on a compact layer [which has isolation in an internal-surface side], and outside-surface side -- it has an aperture with distribution and the effectiveness of this invention is demonstrated.

[0010] Hole distribution of the film of this invention is evaluated by carrying out image analysis of the scanning electron microscope photograph of the outside surface of the desiccation film. The silver vacuum evaporation of the film freeze-dried from cold ethanol is carried out after rinsing the aperture maintenance material and sealing liquid which specifically adhered to the film, and the outside-surface photograph of the film in one 6000 times the scale factor of this is taken with an

electron microscope. printing this on 90mmx70mm magnitude, downloading all the range of a photograph to a personal computer using image-analysis software, and carrying out binarization of the image -- each aperture of an outside surface -- a hole -- it can ask for area. consequently, this invention persons -- a hole -- it found out that fixed relation also between that fixed relation between distribution of area, average hole area, and the amount of piece invasion of a sulfur granule in dialysing fluid and moldability is and hole density, and a moldability was, and there was the need of controlling all.

[0011] Although the abundance of a hole which has a specific hole area is explained in the first place first, with the abundance as used in the field of this invention, it is defined as the percentage of the total of the hole of the hole area of the arbitration to the total of the hole in the captured image, and is given by the following formula (3). In addition, it was regarded as the noise and 10 pixels or less were excepted from counting.

Abundance (%) = (total of hole in total / image of hole of hole area of arbitration) x 100 (3)

[0012] Usually, although some dialysing fluid flows into the porous section inside the film from the aperture of a membranous outside surface, if the piece of a sulfur granule of the origins, such as a coupler, is contained in the dialysing fluid, the piece of a sulfur granule will invade to the interior of the film, a part of physical endotoxin at the time of invasion shocking and isolated from the piece of a sulfur granule may pass a compact layer, and it may shift to a blood side. Generally, for the magnitude of a fungus body, since a major axis is 1-3 micrometers, hole area is 2.0.5 micrometers. Below, invasion of the piece of a sulfur granule hardly takes place. In order to prevent invasion of the piece of a sulfur granule as a matter of fact, it is hole area 0.5micrometer². It is required to stop the abundance of the above hole to 10% or less, and it is still more desirable when it stops to 7% or less. But it is 5% or less preferably. If holes with small one side and hole area increase in number too much, the problem on molding will tend to arise shortly. especially -- a hole -- area -- 0.1micrometer² Fixing arises by the film which adjoin if the following holes increase in number, and separation of hollow fiber inside and outside becomes imperfect by poor osmosis of the potting agent of a between [film]. for losing poor molding by such fixing -- a hole -- area -- 0.1micrometer² It is necessary to press down the abundance of the following holes to 75% or less. It is 45% or less most preferably 60% or less.

[0013] Although average hole area is explained to the second, with the average hole area as used in the field of this invention, it is defined as the average of the hole area of all the holes in the captured image, and is given by the following formula (4). Here, it was regarded as the noise and 10 pixels or less were excepted from counting.

Average hole area = hole total in total / image of the hole area in an image (4)

Average hole area is also related not only to invasion of the piece of a sulfur granule but fixing of moldability, especially film. The inclination which the film which adjoin, so that it is small fixes becomes strong, and this tends to produce poor molding. Since invasion of the piece of a sulfur granule takes place so that it is large on the contrary, it is 2.0.05-0.35 micrometers. It is necessary to hold down to the range. more -- desirable -- 0.10-0.30micrometer² -- most -- desirable -- 0.10-0.20micrometer² It is the range.

[0014] On the other hand, in addition to these parameters, the hole density of an outside surface is also an important parameter on shaping. With the hole density as used in the field of this invention, it is defined as the percentage of total of the hole area of the aperture to the area of the captured image, and is given by the following formula (5). Here, it was regarded as the noise and 10 pixels or less were excepted from counting.

Hole density (%) = (total [of the hole area of an aperture] / area of captured image) x 100 (5)

[0015] Hole density participates in the contribution to fixing of film greatly, its touch area of the film which adjoin if hole density is small increases, fixing takes place, and when severe, the whole bundle may fix in the shape of a rod. For this reason, hole density needs to secure 10% or more. However, shortly, if hole density is enlarged superfluously, as a result of [to the membranous direction of a major axis] coming to carry out, namely, spoiling nerve, poor molding by the yarn flow in the potting section will occur frequently at the time of molding. In order not to spoil nerve, hole density should make 30% an upper limit, therefore the range of the hole density of an outside surface needs to be 10 - 30%. The more desirable range is 15 - 30%.

[0016] Next, it illustrates as an approach of manufacturing the polysulfone system porous membrane

of this invention, about the case where a polyvinyl pyrrolidone (henceforth PVP) is used for a hydrophilic giant molecule. The film production undiluted solution used in order to manufacture this film makes a basic constituent polysulfone system resin, PVP, and three components of a solvent. As a presentation of a film production undiluted solution, the concentration of polysulfone system resin is usually 15 – 20 % of the weight preferably ten to 25% of the weight that what is necessary is just the range which has the viscosity which can produce a film and can demonstrate the description as film. At less than 10 % of the weight, since a polymer consistency will increase, a practice through-hole will decrease and sufficient penetrable ability will not be obtained if sufficient reinforcement as film cannot be obtained but it exceeds 25 % of the weight, it is not practical. These polysulfone system resin is enough, if the thing of 10,000–50,000 is marketed and weight average molecular weight uses it. Especially limitation is not carried out.

[0017] PVP is used in order to hole-form, and for polysulfone system porous membrane to mainly remain and to make a hydrophilic property give. a hole [in / to a surprising thing / in the rate of PVP and polysulfone system resin / the outside surface of hole formation, especially the film] -- participating in formation was found out as a result of wholeheartedly research of this invention persons. Although a detailed principle also has a still unknown part, it is thought to polysulfone system resin that it is the main factors that the molecule size of PVP is far large. That is, if it becomes low in the range with the rate of PVP to polysulfone system resin, the breathed-out undiluted solution viscosity will fall, the microfacies separation rate by diffusion of PVP will be rash, and fusion of the vesicle comrade of PVP will progress. Consequently, although it is few as a number, a hole with a comparatively large area is formed. If the rate of PVP becomes high on the contrary, the fusion rate of the vesicle comrade of PVP will fall for the rise of undiluted solution viscosity, and it will be thought that many holes with an area small as a result with which a deposit of polysulfone system resin advances on the other hand are formed, and hole density also becomes high.

[0018] Thus, when a hole with a large area is shown in a membranous outside surface, possibility that the endotoxin which the piece of a sulfur granule in dialysing fluid trespassed [the number] upon the interior of the film from the hole at least, and separated with the physical shock at the time of invasion will pass a compact layer, and will shift to a blood side even if arises. If holes with an area small on the contrary increase in number, fixing of film will increase, or hole density increases too much, membranous nerve falls, and it becomes the factor of poor molding. Therefore, in order to fill the above, 0.25–0.45 have a desirable rate to the polysulfone system resin of PVP in a film production undiluted solution, and it is still more desirable if it is 0.30–0.40.

[0019] Especially limitation is not carried out that PVP should just use them since various classes are marketed according to molecular weight. However, while it is important for puncturing of an outside surface as mentioned above, there is also the purpose which carries out hydrophilization of the film front face. Since it is in that inclination from this viewpoint so that what is easy to remain on a film front face at the time of film production is desirable and molecular weight is large, it is good for weight average molecular weight to use at least 100,000 or more things. Although both solvents are solvents which dissolve polysulfone system resin and PVP and are chosen from dimethyl sulfo KISHINDO, N,N-dimethylacetamide, N,N-dimethylformamide, a N-methyl-2-pyrrolidone, a sulfolane, dioxane, etc., such combination is arbitrary in each. Moreover, little water and salts can also be added in order to control a coagulation rate.

[0020] What is necessary is just to use a well-known dryness-and-moisture type method, in order to obtain polysulfone system porous membrane using the film production undiluted solution which consists of the above system. A film production undiluted solution and internal coagulation liquid are introduced into coincidence at discharge and a coagulation bath from the annular nozzle (duplex spinneret) of the double tubing structure kept warm by 30–60 degrees C. In that case, air transit is carried out, before introducing into a coagulation bath from the nozzle regurgitation. Especially the air transit length on the regurgitation side of this nozzle and the front face of a coagulation bath usually has 30–85 desirablecm 10–100cm. As a result of reaching a coagulation bath while coagulation has been imperfect if shorter than 10cm, since a compact layer is formed also in an outside surface, the film of this invention is not obtained. if it exceeds 100cm on the contrary -- a yarn shake -- being generated -- coagulation -- adhesion of imperfect yarn may take place and it is not desirable on a manufacture process.

[0021] Moreover, the ambient atmosphere of the air transit section is also important when attaining this invention, the transit section circumference is enclosed and sealed with a hood, and the interior is held to a damp or wet condition. A damp or wet condition uses the steam generated from a lower coagulation bath, adjusts the temperature of a coagulation bath in 30–70 degrees C, and should just saturate the inside of a hood with a steam. It is the range of 45–60 degrees C more preferably. As for internal coagulation liquid, it is desirable for spinning stability to be [it] better to use a thing lower than the high thing of freezing characteristic to a film production undiluted solution, and to use the mixed liquor of water and a solvent. It is chosen from N,N-dimethylacetamide, N,N-dimethylformamide, a N-methyl-2-pyrrolidone, dimethyl sulfoxide, etc. as a solvent. A solvent is 5 – 40 % of the weight, and the remainder of the desirable presentation of internal coagulation liquid is water. If the rate of water increases more than this, permeable ability sufficient as film may be unable to attain. A solvent is 10 – 25 % of the weight more preferably.

[0022] The hollow filament made to solidify as mentioned above has the unsymmetrical vesicular structure to which it has a compact layer in an internal-surface side, and it has an aperture in an outside surface. After rolling round this hollow fiber to skein and cutting into fixed bundle length, an extant solvent is rinsed, and if for example, a glycerol water solution is made to adhere and desiccation processing is performed at 70–80 degrees C for 10 hours or more, subsequently to before desiccation processing, the film of this invention will be obtained as an aperture hold-back agent. In case the film concerned is used, it casts to the module which carries out potting of the both ends with polyurethane etc., and has a predetermined film surface product, and sterilization processing is performed if needed. Especially limitation is not carried out that a modularization should just follow a well-known approach. What is necessary is just to process ethylene OKISAITOGASU sterilization, autoclave sterilization, radappertization, etc. that what is necessary is just to also choose the sterilization approach from a well-known approach according to an application.

[0023]

[Embodiment of the Invention] Next, although an example and the example of reference explain this invention to a detail, this invention is not limited to it. In addition, many numeric values used in the example were measured with the following procedures. (The hole area of an outside surface, abundance of a hole, and hole density) the film -- a stream -- it was made to freeze-dry by dry ice content ethanol after 1-hour rinsing in the bottom It fixed to the sample base of dedication of this film, and the outside-surface photograph 6000 times the scale factor of this was taken after silver vacuum evaporationo with the scanning electron microscope (made in Hitachi: call it SEM S-2460 Ns and the following). The image processing incorporated this photograph (90mmx70mm) with the image scanner, and carried out the incorporation range with whole photograph surface, resolution 320, and brightness 2,256 gradation using processing software (the product made from KOSHIN GURAFIKU cis- TAMUZU: the color magician 7, version 1.0). Binarization of this image was carried out with processing software (a NIH image, version 1.57), and the hole area of each hole was computed. In addition, it considered that an image 10 pixels or less was a noise, and it was excepted from counting. Moreover, the hole of the perfect circle in the membrane filter (Millipore [Corp.] make: eye SOPOA, hole diameter of 2 micrometers) to which the aperture was equal with electron beam irradiation was measured simultaneously, and carry BURISHON was performed.

[0024] (Sulfur granule reverse filtration trial) Dialysing fluid (AK-Solita and DL, the Shimizu Pharmaceuticals incorporated company make) was prepared using the high sulfur granule content water solution which carried out private creation. It substituted measuring the content of endotoxin for the used amount of sulfur granules. The circuit which contains the sulfur granule contamination dialysing fluid of 15800EU / liter as endotoxin concentration was connected to the module dialysing fluid close side, and the plug was turned on the dialysing fluid appearance side. The plug was turned for the circuit on the modular blood appearance side at the connection and blood close side. Set the pump to the dialysing fluid close side circuit, 2l. was made to reverse-part [for 200 cc/of the rates of flow] filter to a blood appearance side, and reverse filtrate was extracted after discharge and from a blood appearance side. The quantum of the amount of endotoxins contained in the extracted reverse filtrate was carried out by end SUPESHI – (Seikagaku make: ES-50 set), and the reverse filtration fraction was computed from the following formula (6). In addition, C0 in a formula shows the endotoxin concentration in dialysing fluid, and C1 shows the endotoxin concentration in reverse filtrate.

Reverse filtration-fraction (%) = $(C1/C0) \times 100$ (6)

[0025]

[Example 1] At 50 degrees C, it stirring-dissolved, degassing of 17 % of the weight (the product made from Amoco-- 1700) of polysulfone system resin, 7 % of the weight (BASF [A.G.] make: K90) of PVP, and the 76 % of the weight (henceforth DMAc) of the N,N-dimethylacetamide was carried out for 8 hours, and the film production undiluted solution was obtained. It mixed with internal coagulation liquid and it prepared 15 % of the weight of DMAc, and 85 % of the weight of water. It was made to breathe out from the duplex spinneret which kept warm this film production undiluted solution and internal coagulation liquid at 55 degrees, and introduced into the coagulation bath through the 60cm air transit section sealed with the hood. The coagulation bath considered as 52.5-degree C warm water, and the interior of a hood suited the saturation state of a steam. The coagulation bath was passed and hot water washed the film rolled round to skein. 15% of the weight of the glycerol water solution was made to adhere as an aperture hold-back agent furthermore, and desiccation processing was performed at 70 degrees C for 12 hours. It is the obtained film 1.5m of film surface products 2 Polyurethane was used and cast to the module, it was filled up with water, and the gamma ray of 25KG(ies) was irradiated. Hole area 0.5micrometer2 [in / as a result of carrying out an image processing based on the SEM photograph which shows this film to drawing 1 / an outside surface] The rate of the above hole is 3.0% and hole area 0.1micrometer2. As for average hole area, at 42.9%, 0.16 micrometers of the percentages of the following holes of 2 and hole density were 15.5%. This film did not have fixing and the moldability was good. Moreover, since the endotoxin concentration in reverse filtrate was below limit of detection (below 9.0EU / liter), it did not accept invasion as a matter of fact.

[0026]

[Example 2] 17 % of the weight (the product made from Amoco-- 1700) of polysulfone system resin, 4.5 % of the weight (BASF [A.G.] make: K90) of PVP, and 78.5 % of the weight of DMAc were mixed, at 50 degrees C, it stirring-dissolved, degassing was carried out for 8 hours, and the film production undiluted solution was obtained. It mixed with internal coagulation liquid and it prepared 20 % of the weight of DMAc, and 80 % of the weight of water. The desiccation film was obtained on an example 1 and these conditions except having made air transit length to 45cm, and having made coagulation bath temperature into 65 degrees C. It is the obtained film 1.5m of film surface products 2 Polyurethane was used and cast to the module, it was filled up with water, and the gamma ray of 25KG(ies) was irradiated. Hole area 0.5micrometer2 [in / as a result of carrying out an image processing based on a SEM photograph like an example 1 / an outside surface] The rate of the above hole is 9.3% and hole area 0.1micrometer2. For the percentage of the following holes, at 39.6%, average hole area was [0.19 micrometers of 2 and hole density] 10.6%. This film does not exist, either and fixing has cast it good. Moreover, since the endotoxin concentration in reverse filtrate was below limit of detection (below 9.0EU / liter), it did not accept invasion as a matter of fact.

[0027]

[The example 1 of a comparison] 17 % of the weight (the product made from Amoco-- 1700) of polysulfone system resin, 9.0 % of the weight (BASF [A.G.] make: K90) of PVP, and 74.0 % of the weight of DMAc were mixed, at 50 degrees C, it stirring-dissolved, degassing was carried out for 8 hours, and the film production undiluted solution was obtained. It mixed with internal coagulation liquid and it prepared 20 % of the weight of DMAc, and 80 % of the weight of water. The desiccation film was obtained on an example 1 and these conditions except having made air transit length to 60cm, and having made coagulation bath temperature into 55 degrees C. It is the obtained film 1.5m of film surface products 2 Polyurethane was used and cast to the module, it was filled up with water, and the gamma ray of 25KG(ies) was irradiated. This film is hole area 0.5micrometer2 in an outside surface. The rate of the above hole is 0.8% and hole area 0.1micrometer2. The percentage of the following holes was 88.5% and 0.03 micrometers of 2 and hole density of average hole area were 3.3%. After desiccation was not able to be cast, if film fixing was intense and remained as it was. When it repaired and the sulfur granule reverse filtration trial was carried out after molding, the endotoxin concentration in reverse filtrate did not accept invasion as a matter of fact below limit of detection (below 9.0EU / liter).

[0028]

[The example 2 of a comparison] 17 % of the weight (the product made from Amoco-- 1700) of

polysulfone system resin, 3.5 % of the weight (BASF [A.G.] make: K90) of PVP, and 79.5 % of the weight of DMAc were mixed, at 50 degrees C, it stirring-dissolved, degassing was carried out for 8 hours, and the film production undiluted solution was obtained. It mixed with internal coagulation liquid and it prepared 15 % of the weight of DMAc, and 85 % of the weight of water. The desiccation film was obtained on an example 1 and these conditions except having made air transit length to 45cm, and having made coagulation bath temperature into 25 degrees C. It is the obtained film 1.5m of film surface products 2 Polyurethane was used and cast to the module, it was filled up with water, and the gamma ray of 25KG(ies) was irradiated. a hole [in / in this film / an outside surface] -- area -- 0.5micrometer² the rate of the above hole -- 47.5% and a hole -- area -- 0.1micrometer² The percentage of the following holes was 18.8% and 0.59 micrometers of 2 and hole density of average hole area were 35.8%. Although there is no film fixing after desiccation and molding was completed, yarn flow was seen over the whole potting section. When the sulfur granule reverse filtration trial was carried out, the reverse filtration fraction is 0.13% and reverse filtration of the endotoxin by invasion of the piece of a sulfur granule was accepted.

[0029]

[Effect of the Invention] Since the piece of a sulfur granule contained in dialysing fluid moreover trespasses upon the interior of the film and reverse filtration of endotoxin does not take place as a matter of fact, without causing poor molding by film fixing at the time of manufacture, the polysulfone system porous membrane of this invention can be suitably used in the blood purification field.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] As an example of the film obtained by this invention, the SEM photograph (one 6000 times the scale factor of this) of the film obtained in the example 1 is shown.

[Translation done.]

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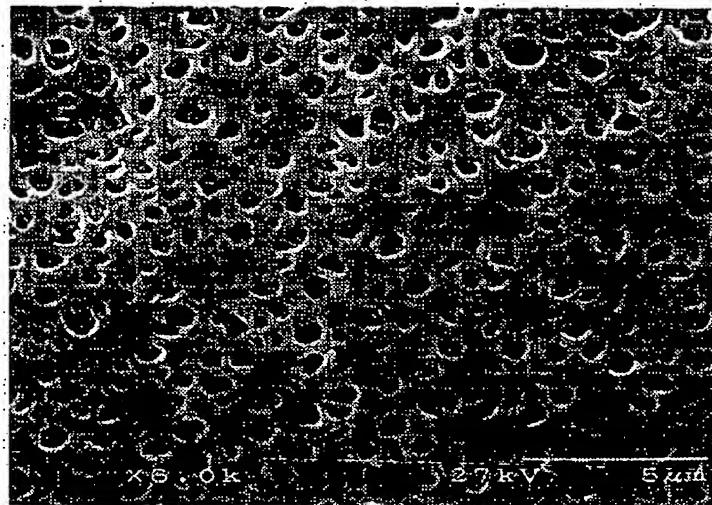
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DRAWINGS

[Drawing 1]

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[Translation done.]